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AUTHOR Bierschenk, Bernhard
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ABSTRACT

Because computer-oriented researchers apply cognitive notions such as meaning, symbol and understanding, or concept, cognition and knowledge, it has become mandatory to inquire into the traditional explanatory models of science, including behaviourism. The article outlines the steering and control mechanism that has governed a new outlook in which subjective mental states become functionally interactive and essential for a full explanation of conscious behaviour. The presented model has governed a comprehensive exploration into Cognitive Science. Its purpose was to digest the viewpoints of "hard" science and to compare the transformation with the value-assumption underlying many of the approaches favoured by behavioural scientists. Advanced methods have been developed. For this reason, they have been analysed with respect to changes in both intention and orientation. These processes are highly dependent on the relations between natural language expressions and their underlying mentality. It is demonstrated that the frequently occurring non-additive effects of cognitive functions as design variables necessitate a research effort that concentrates on the instrumental functions of natural language. Each of the identified functions is studied as variable on the basis of a recurrent two-by-two factorial design. The approach stresses the fact that a variable in one developmental phase is treated as independent variable, whereas its re-appearance in the succeeding phase results in its treatment as dependent variable. The study of co-variation and interaction of the variables seems to be the only way to shed light on the confounded discussion of the traditional science-value dichotomy in Cognitive Science. The new methodological approach consists of a calculus that preserves responsibility as its constituent component. The calculus has progressively been introduced during the development of the presented double helical architecture, which is the result of an unfolding of the AaO-formula into a cognitive system. Seven figures illustrate the discussion. (Contains 82 references.) (Author)

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Bernhard Bierschenk

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Lund University
Sweden

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Bernhard Bierschenk

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Cognitive Science Research

Lund University
Sweden

Postal address

Cognitive Science Research
P.O. Box 7080
S-220 07 LUND
SWEDEN

Editor

Bernhard Bierschenk
Department of Psychology
Lund University

Adm. editor

Helge Helmersson
Department of Business Adm.
Lund University

Abstract

Because computer-oriented researchers apply cognitive notions such as meaning, symbol and understanding, or concept, cognition and knowledge, it has become mandatory to inquire into the traditional explanatory models of science, including behaviourism. The article outlines the steering and control mechanism that has governed a new outlook in which subjective mental states become functionally interactive and essential for a full explanation of conscious behaviour. The presented model has governed a comprehensive exploration into Cognitive Science. Its purpose was to digest the viewpoints of "hard" science and to compare the transformation with the value-assumption underlying many of the approaches favoured by behavioural scientists. Advanced methods have been developed. For this reason, they have been analysed with respect to changes in both intention and orientation. These processes are highly dependent on the relations between natural language expressions and their underlying mentality. It is demonstrated that the frequently occurring non-additive effects of cognitive functions as design variables necessitate a research effort that concentrates on the instrumental functions of natural language. Each of the identified functions is studied as variable on the basis of a recurrent two-by-two factorial design. The approach stresses the fact that a variable in one developmental phase is treated as independent variable, whereas its re-appearance in the succeeding phase results in its treatment as dependent variable. The study of co-variation and interaction of the variables seems to be the only way to shed light on the confounded discussion of the traditional science-value dichotomy in Cognitive Science. The new methodological approach consists of a calculus that preserves responsibility as its constituent component. The calculus has progressively been introduced during the development of the presented double helical architecture, which is the result of an unfolding of the AaO-formula into a cognitive system.

The foundation of knowledge has been the central subject in philosophy and epistemological study during centuries. Despite the fact that many books and journals have been published on the matter, it is difficult to discern a generally accepted definition or basis. The problem of knowledge has primarily been characterised as "theoretical" (Bunge, 1967) and therefore inappropriate for a scientific approach on empirical grounds. Epistemologists seem to maintain the position that experimentally working scientists certainly are able to pile up lots of quantitative data and are able to apply statistical analysis on them. But they take for granted that this activity will not lead to an understanding of the phenomenon. To epistemologists it is evident that an understanding of the human mind requires a study of how human beings should think, which is intimately related to the study of the universals of logic, language, and symbolism in general. Due to the fact that there is no way of proposing a formal definition, and due to the circumstance that the notion to an ever increasing extent is used as synonym of information, the approach chosen here to study the phenomenon of information synthesis is process-oriented. This implies that a "demonstrative definition" in Sommerhoff's (1950) sense will be given.

The fundamental assumption underlying the demonstrative definition of Cognitive Science to be developed in the following is that behavioural or symbolic expressions in which self-indication is concealed, deprive us of the possibility of interpreting what has been expressed. Thus "self-recognition" and the attribution of "intention" (Gallup, 1970; Gallup, Boren, Gagliardi & Wallnau, 1977; Povinelli, 1993) and consequently self-reference must be discovered when a behavioural or verbal expression is to serve as starting-point for information processing. Observing behaviour in individuals acting purposely in a meaningful environment is hardly possible without the organism's expression of an "intended" and "oriented" schematising process. Observation presupposes not only that a structure can be specified but also that intentionality and orientation can be observed. In order to get hold of the intention it becomes necessary to apply the AaO-formula (B. Bierschenk, 1984 a, p. 11) to the observation. This will be illustrated with Figure (1).

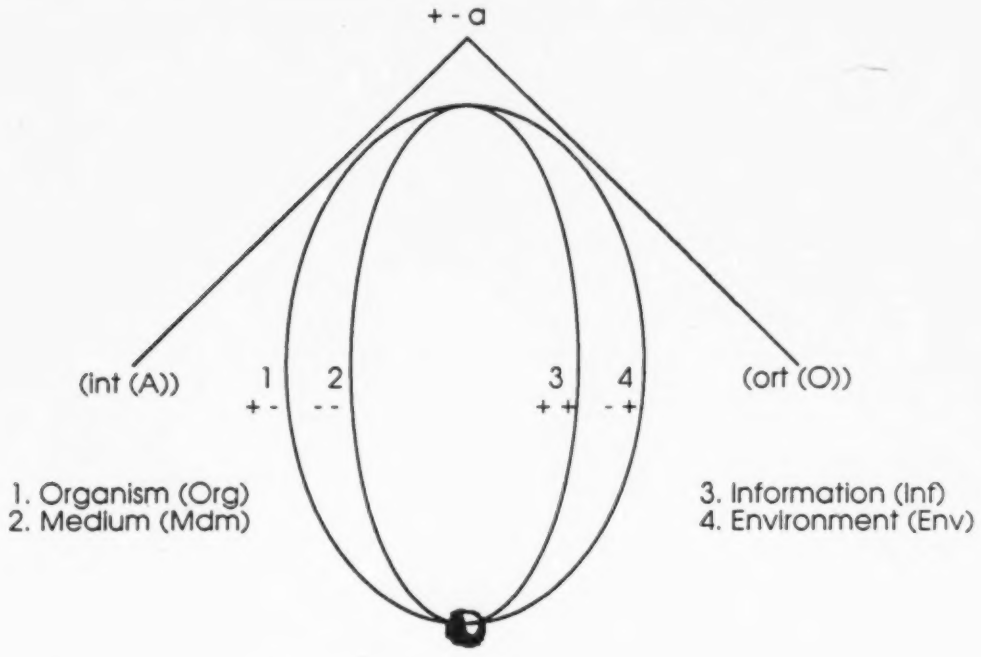
The structure embedded in the AaO-formula may be visualised as a complementary arrangement of its components in a three-dimensional space. For simplicity, the developing system will be presented in two dimensions. The dispension point at the top of Figure (1) is defined by the action component of the AaO-formula. The values (-, +) in front of the symbol (a) indicate that the A- and O-components are qualitative, which means that their manipulation corresponds to two types, the presence or absence of a variable carried by the respective component. Binding these values with regard to the complementary roles of A and O results in four non-linear dimensions describing the event space of Figure (1). The anticipated process starts with an attribution of intention to the A and orientation to O, which gives (int (A)) and (ort (O)) as the design variables of the system in Phase (0).

The first measure that can be carried out by the experimenter is that he can fixate the variable of intention by binding the value (-) to it. The second measure may imply that the experimenter chooses to bind the value (-) right adjusted. The result is depicted by curve (2) carrying (- -), which marks the existence of homogeneity or uniformity due to the fixation (or absence) of both intention and orientation. If one may assume with Gibson (1979) that expressive behaviour manifests itself in uniform light, this would imply that light is a medium that can carry information. Moreover, information can be studied through non-uniformity which means change. But "regularities in change" can be sensibly measured only with reference to a particular organism as outlined in Figure (1).

This is the fundamental theme developed in B. Bierschenk (1984 a). Here it is presumed that the development of an organism in a certain direction depends on changing intention. The third measure then implies that the experimenter left adjusted binds the value (+) to intention. The curve (1) carrying (+ -) takes its point of departure in the assumption that an organism being able to express itself freely creates information of high quality and validity.

Thus, inherent in the process of communication is the process of transforming meaningful behaviour into symbolic expressions. Isolating the A-component's effect makes "propriospecific" information measurable.

Figure 1. Phase 0. Information Processing by Living Systems.



Gibson's ecological theory incorporates some observations concerning classical approaches to perception. An interpretation makes clear that a lifting of information from its carriers is dependent on changing orientation. Thus, the fourth measure to be taken by the experimenter requires him to bind the value (+) right adjusted. This produces a separation of "exterospecific" information, because no change in intention is implied.

It is further assumed that any meaningful behaviour entwines both intention and orientation (Monod, 1971), because the perception of the environment is an activity that twines together the perceiver with the perceived in an interactive relation, without which the meaning of the perceived cannot be established. The relation thus described can be observed by the co-operative interaction of both the A- and O-component. The result is carried by curve (3). The value combination (+ +) suggests a synthesis which makes information a quality that emerges as a result of a co-operative process presupposing the possibility of tying the effect of an experience to a related activity instead of attributing it to some unrelated mechanism.

Finally, the relations (- -, + +) and (+ -, - +) are complementary to each other. This double asymmetry gives every pair a certain control over the development of every other. The asymmetrical pairs constitute the mechanism for the developmental control over observational differentiation and integration of basic concepts. The emerging system performs a functional control over the development in the design, measurement, and representation of cognitive processes. The significance of the system's double mechanism of change lies partly in an instrumentation of experiments and other research efforts, partly in an explanation of cognitive development. This process of analysis and synthesis will be demonstrated and discussed on the

basis of a number of studies which by now have become classical. The procedure may help to contextualize less known approaches and to put them into proper perspective. The leading idea of this approach is that knowledge must be understood in terms of the agent rather than of a physical, symbolic or conceptual entity as referent. In a different context Kugler and Turvey (1987, pp 67-107) have developed this idea with respect to the "co-operativity of complex atomisms", i. e. living systems.

The Communication of Living Systems

Starting with Phase zero (0) means that informative components emerge only if uniqueness can be detected or if known information can be transformed. Through careful and thorough control of intention and orientation, Frisch (1967) investigated whether sounds and movements in bees are utilizable by other bees in order to extract informational invariants. What is measured is whether and to what extent sounds and movements are art specific carriers of information. This process is assumed to develop into a singularity (the filled circle in Fig. 1).

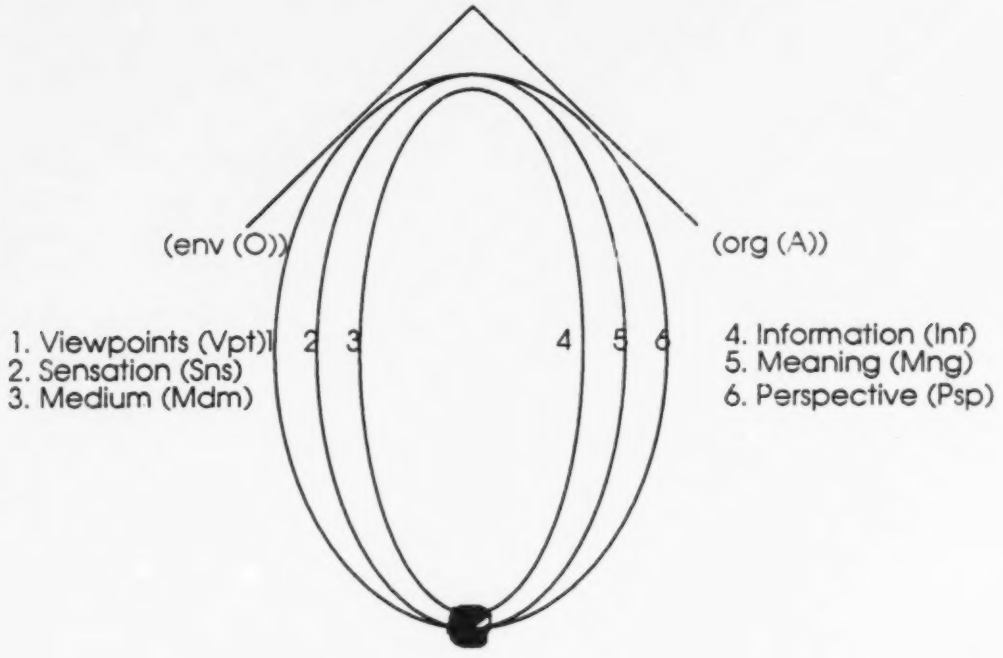
For demonstrative purposes it has be shown (B. Bierschenk, 1984 a), that Frisch (1967) in his methodological approach, was concerned with the ability of isolating the A-component's effect so as to make available "propriospecific" information. The basic hypothesis has been that this is the constitutive component that reflects a schema in Kant's (1975) sense, which can be controlled. By making his reasoning the foundation of measurement and representation gives as dependent variable the variations in an environment (Env), which can be achieved by changing the landscape or by moving an organism into different locations. Variations in the organism (Org) as dependent variable, on the other hand, is achievable by experimenting with an artificial mixing of organisms in order to reflect success in the manipulation of intention. A fixation of intention and orientation, on the other hand, may be regarded as *the zero hypothesis of behaviour* since, in this state, the organism is unable to lift the information from its carriers.

Development of Meaning

The novelty of Phase (I) starts with a twist at the singularity produced during Phase (0). This means that the curves carrying the measurable, i. e. the dependent variables, of Phase 0 now come to the experimenter's disposition as independent variables. By completion of this process intention and orientation have been transformed with the result that a new singularity has been produced. Through a complementary arrangement a new set of novel characteristics can be determined as is demonstrated in Figure (2). That which operates now is embedded in the "environment" (env (O)) - "organism" (org (A)) co-operation. Intention is transformed and in this state carried on by the perspective (Psp) (6) while orientation is transformed into the viewpoints (Vpt) (1).

This means that intention and orientation can only secondarily influence the co-operation between organism and environment. The innermost curves transfer the medium (3) for carrying information (4) into the new phase, while the inner curves represent the novel integration (2) and synthesis (5), namely "sensation" and "meaning" respectively. Differentiability in ecological information processing is bound to "viewpoints" (1) and "perspective" (6) which can be measured and represented. Therefore, both may be treated as the dependent variables of Phase (I). In B. Bierschenk (1984 b), cognitive development terminating in the singularity of Phase (I), is based on the assumption that the mechanism preserves the origin of the cognitive process (3, 4), but integrates (2), and synthesises (5), which becomes manifested in corresponding emergents. But novel differentiations provide for changes in the characterising function of the mechanism. This circumstance is manifested in corresponding qualitative changes of the nature of information as shown in Figure (2).

Figure 2. Phase I. Ecological Information Processing



The discussion of ecological information processing starts with Becker (1978) and outlines its relation to the concept of meaning. The argumentation relies on a series of experiments which in an elucidatory way have demonstrated that perception cannot build on randomly dispersed elements within a visual field to represent something meaningful. It is rather a result of an organism's response to informational invariants carried by the relations that exist between organism, object, and event within a given optical array. The conclusion to be drawn is that an organism must have been endowed with a mechanism that detects these invariants, i. e. affordances in its environment. The validation of the assumption that sensation and meaning are acting interactively is demonstrated with a description and analysis of the famous Visual Cliff experiments (Gibson & Walk, 1960), because these have been designed to study empirically whether an intentional use of ecological invariants can be demonstrated.

Apart from demonstrating the development of meaning, the Visual Cliff experiments serve as point of departure for a formal analysis of cognitive growth. Therefore, parts of a computer model (Becker, 1973) developed to simulate an organism's strategy of information pick-up and schematising has been analysed. Underlying this model is the assumption that environmental conditions cause the forming of behavioural habits, which become "internalised" (Piaget, 1963). The algorithmisation is studied and criticised with reference to questions about what logic or logics are utilised in the modelling of an organism's various functions (B. Bierschenk, 1984 b, pp. 10-11).

Since ecological perception is defined through behaviour within the framework of the observer-event involvement, there are some good preconditions for a successful simulation of the development of meaning in Becker's approach. With the results obtained from both the formal and the informal demonstrations, it was possible to discuss whether such elementary processes as (1) conditional judgement (if-then anticipation), (2) classification (generalisation) and (3) comparison (combination) can be conceived of as belonging to cognitive information

processing. Because these are essentially unlearned activities that can be conditioned (by Becker's model) they cannot serve in a model that orients cognition toward novel solutions.

It is of fundamental importance for classical approaches to freeze both organism and environment by thorough controls of possible variations in the organism and of the stimulus material. The essential requirement in this type of study is, according to Johansson (1974, p. 132), "the arrangement of a stationary environment seen by a stationary eye", Thus freezing the experimental factors in Phase (I) means that sensation (2) represents the *zero hypothesis of perception*. In conclusion, it is demonstrated that Becker simulates motor adaptation to visual stimulation, i. e. sensation. This attempt of formalising perceptual processes is founded on the general approach taken in Cognitive Science, namely the syntagmatic.

Natural Language Understanding

Phase (II) is marked by a manipulation of "perspective" (psp (A)) and "viewpoint" (vpt (O)). As a consequence new measuring variables (1, 8) and a new integration (2) as well as a new synthesis (7) emerge. The process now has moved (3, 4, 5, 6) from ecological into symbolic processing which integrates the study of natural language into Figure (3). Because the symbol itself is frozen (2) and treated as a stimulus, it represents the *zero hypothesis of understanding*. In agreement with the general conviction, at least in Cognitive Science, the frozen symbol allows for such operations as addition, deletion, and insertion. These operations presuppose that the symbol is a *primitive* on which the operations can be performed according to formally defined rules. In this connection, the necessary semantics of a symbolic expression is attributed to propositional knowledge statements about the world and tested on the basis of truth conditions.

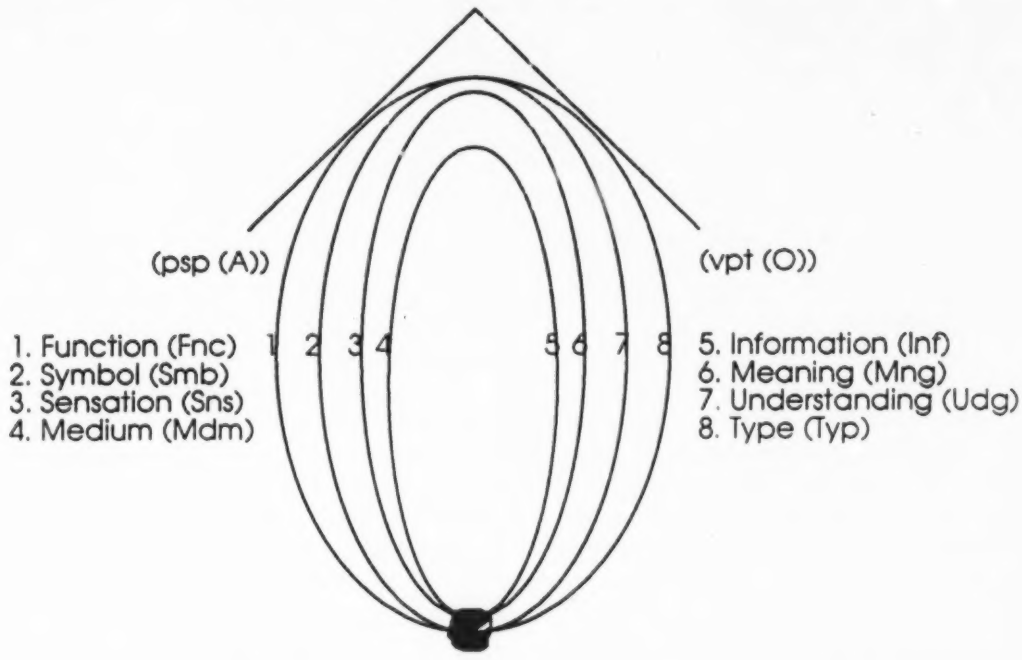
Applied to the processing of natural language expressions, such as English, the computer approach has as its effect that the significance of a sentence is proposed to be the essence of its underlying propositions (Simon, 1981). This conception has created a scientific handling of language requiring that anything subjective (related to a perspective) has to be kept out of the scientific process. Consequently, the import of symbols thus defined is normatively imposed and considered independent of intention. Though, what works during this Phase (II) is the experimenter's manipulation of (psp (A)) and (vpt (O)) in order to produce variations in function (1) and variations of type (8). These operations can only be regarded as a transformational twist, leading to the development of a new singularity in Figure (3).

Founded on formal notation systems, a short introduction to some of the ideas that have governed computer scientists in their definition and explanation of language is given in (B. Bierschenk, 1986). The way they conceive of symbol processing (2) naturally leads to a study and discussion of semantic networks. These are demonstrated with Quillian's (1968) "Teachable Language Comprehender". Natural language, unambiguously defined by such an approach constitutes the starting-point for many of the computer programs aimed at simulating language understanding.

Understanding as predication. Basically, stored syntactic patterns or linguistic features are matched with letter strings. The system of rules steering and controlling this matching is taken as the operationalisation of the "behaviour" of the syntactic models and conceived of as being synonymous with a theoretical explanation of the understanding of a given verbal expression. Quillian's model illustrates how language and language comprehension are treated. It is utilised as the primary basis for the conceptualisation of further developments within Cognitive Science. Another reason for focusing on this model is that it laid the groundwork to propositional knowledge representation in the form of semantic nets. On the basis of semantic nets symbols could be studied with respect to a particular type of pattern.

Understanding as state change. Typical of an analysis of the *functional* (1) aspect of language is that it concerns objects belonging to the same logical type. If language expressions are seen as regularised patterns of symbols of a certain kind, it becomes important to study the

Figure 3. Phase II. Symbolic Information Processing



power of various expressions. This was Winograd's (1972) starting-point in his analysis of natural language understanding as change in state. Winograd's work is concentrated on finding methods for measuring changes in the functions of language. His approach is a formal attempt to a verbal description of computer vision, which is of particular relevance for a formulation of criteria on the basis of which knowledge processes can be isolated and tested. Winograd's attempt to use geometrical configurations may be seen as a valuable contribution to an understanding of the line function in the cognitive process and the resulting concepts and conceptual relations.

Because Hubel and Wiesel (1963) have been able to show that young kittens without visual exposure by and large have the same physiological system of contour coding as adult cats, it is of interest to compare Winograd's approach with Andersen's (1975) study of the line function in a contour coding experiment. Her scientific problem has been children's arriving at the understanding of different objects of the same logical type. Since Winograd seems to conceive understanding as functional, i. e. as integrated in artificial perception, the comparison between the two approaches may point at some significant differences between artificial and natural intelligence. For example, seen in a developmental perspective, children look at objects in relation to the events in which the objects have been involved. From a perceptual point of view, the dynamic interaction between type and function leads to the abstraction of higher-order functions, which seem to underlie categorisation efforts. In conclusion, the importance of context such as cultural experience is obvious in this kind of learning. It implies that there is a *value* integrated with the function without which the transformation from one type of experience to another would have no cognitive sense. Winograd's "SHRDLU" cannot even understand the logic of one type of experience, since function and value are kept apart. Human understanding is parasitic on values that by nature are "evolutionary, interrelated, and conditional on the context in which they evolve" (Sperry, 1993, p. 883).

Ecological events have a certain value character, which can be processed only to the extent that they are mediated by the parts of a language (e. g. modality, quality or quantity).

The perception that can be discriminated according to variations in object orientation reveal ecological information to the organism. After this kind of information has been available the organism can extract the ecological invariants and intentionally express (symbolise) them in a natural language. Regan, Beverly and Cynader (1979) have demonstrated highly specific pathways for the processing of motion specific cues, and this uniqueness is absolutely necessary, because there is no uniqueness of signals. In addition, Ball and Tronick (1971), in a psychophysical experiment, could show that infants of only a few weeks of age can meaningfully respond to symmetrically expanding shadows, optically specifying an approaching object. These topological cues regarding modality and quality are processed in a strictly self-referential way.

Understanding as classification. When the analysis deals with objects of different logical types (8), another well-known approach from Cognitive Science may be representative, namely Schank's (1972) attempt to explain language understanding by "diagrams of conceptual dependency" which has been discussed (B. Bierschenk, 1986). Schank's model is indicative of a strategy founded on image analogy. This line of thought presupposes that an analysis of language understanding requires a method that utilises both a sentence level and a conceptual level. Therefore, the proposed theory assumes that answers to realistic questions can only be given with reference to a knowledge base outside the one prescribed by predicate-logical formulations. Moreover, it is stipulated the requirement that computer programs conform to a *behaviour* model of human language understanding. The modelling is socially oriented due to its reference to actors and scenarios. However, the actor-function is not experimentally controlled in Schank's studies, which has far-reaching consequences for the outcome. Instead the model is anchored in a "case-frame", implying that each linguistic form should, in principle, have only one conceptual diagram representing the information it carries. This view has led the discussion to pose the fundamental question: What does it mean for an analysis of language understanding that the model builds on Aristotelian assumptions? An answer, namely, would tell us what makes Schank conceive language as a static phenomenon and what makes him regard "semantic primitives" as belonging to certain specific classes, which he assigns "labels". In Rosch (1975) an answer to this question can be found. Conscious of the fact that science works with "artificial classes" and their labelling, she studies the way in which they differ from "natural categories" and their naming. With the aim at testing the validity of an approach that treats language as an a priori defined symbolic-logic hierarchy, her results are contrasted with Schank's basic assumptions. In conclusion, categories show an internal structure that contradicts the Aristotelian assumption. Schank uses "stereotypes" in place of Rosch's "prototypes", an approach that has resulted in a dis-orientation with respect to cognition. Essentially, he successively freezes different viewpoints which has manipulated him into the paradox that he moves from conceptualisation to data association, which means that he moves back into the semantic net approach. Despite that it is obvious that an action or any other signal constitutes an "intent" (Howe & Foerster, 1975), Schank, in a classical way, has tried to avoid the self-reference, although typical actions in his theory like "take" and "give" both signal a distinction and prerequire an intention.

Understanding as self-reference. When symbols are considered carriers of information abstracted from expressive behaviour (B. Bierschenk, 1984 a, p. 11) it is implied that they signify "regularised meaning". As demonstrated in B. Bierschenk (1984 b), motor adaptation to visual stimulation is nothing that occurs automatically but requires practice. Moreover it should be clear from the inspection of (Fig. 3) that (3, 6) are deeply embedded in the development of symbols tying the symbol directly to the individual's predisposition (4, 5) of an information pick-up that is direct. The empirically founded development of symbols thus depends on continuous transformations of experiences and practice.

This kind of transformations in a cognitive development has led numerous scientists to attempts of establishing a scientific ground for cognitive processes. In concentrating their

approaches on the analysis and discussion of the notion "symbol", they have unfortunately disregarded fundamental differences in the levels of analysis. At the symbolic level, the transformation entwines the perspective and viewpoints in the same way as organism and environment are entwined at the ecological level. Therefore, the analysis of symbolic expressions could not be carried out successfully before the textual perspective could be detached experimentally from its viewpoints. Of particular importance for the process of detaching the perspective from its viewpoints is the assumption that the empirical observations are linguistically packed in such a way that ecologically valid information can be discovered. By this is meant the particular affordance that objects and events have for the individual at the moment of perception.

In contrast to the conventional approaches, an approach building on the co-operative interaction of both perspective and viewpoints (7) is presented (Bierschenk & Bierschenk, 1984 a-b, 1985, 1986 a-c; B. Bierschenk, 1993 a; Helmersson, 1992). Their theoretical understanding of symbol processing is anchored in Gibson's theory of affordance and consequently the developed model is based on the Visual Cliff presented (B. Bierschenk, 1984 b), which is to say, that it is an experimental approach to empirical observations made in connection with testing the theory of ecological perception.

Through Kennedy's (1975, 1980) studies it further became evident that children's perspectives and viewpoints need not necessarily be interpreted as belonging to the experience of vision, but should be regarded as factors with cognitive properties. Therefore, it became important to treat perspective and viewpoint differentially, since a verbal description of object-event relationships incorporates both optical and perspective invariants. The ability to understand through language presupposes the abstraction and description of these invariants. Thus, direct perception of symbolic information is dependent on what higher-order relations are becoming visible through language for immediate activation.

Characteristic of the conceptual coding presupposed by the Kantian schema is that the agent-function must always be unambiguously discerned and that the empirical context must be known (I. Bierschenk, 1987). When both conditions are met, relations between observer or producer of a text and events on an action level can be specified, something that has significant consequences for processing natural text (B. Bierschenk, 1990 a). The model has been tested on different types of natural text and results reflecting the intended affordances have been presented (e. g. B. Bierschenk, 1993 b; Dahlgren, 1990; Gabrielsson & Paulsson, 1989; Pétursson, 1991). What should be payed special attention to is that the higher order relations abstracted, have structurally been represented by means of topologically described dimensions. The perspective invariants lying in the textual flow have been made visible by the transformations depicted in the form of a cubic space. Within that space, developing cognitive processes have not only been discerned but also been differentiated.

But informational invariants emerge only if self-reference is conceived of as an integrative component in the schematising process. Self-reference implies that no master interpretation can be forced upon a text (B. Bierschenk, 1991 c). Through careful and thorough control of the agent function, intention and orientation can be discerned on the basis of the discontinuities in language production, which makes Perspective Text Analysis scientific in the true sense of the notion science (B. Bierschenk, 1991 d). The novelty of this approach concerns the development of an algorithm in which the Kantian schema interrelates the analytic with the synthetic mode. Based on the constructed formalism, it has been possible to demonstrate perspective and objective structures empirically as the result of a series of non-deterministic bifurcations of a dynamic vector field within Euclidean space. At the symbolic and conceptual level the environment is not only reacted to and acted upon, but is understood through the processing of information picked up from symbols.

Emergence of knowing

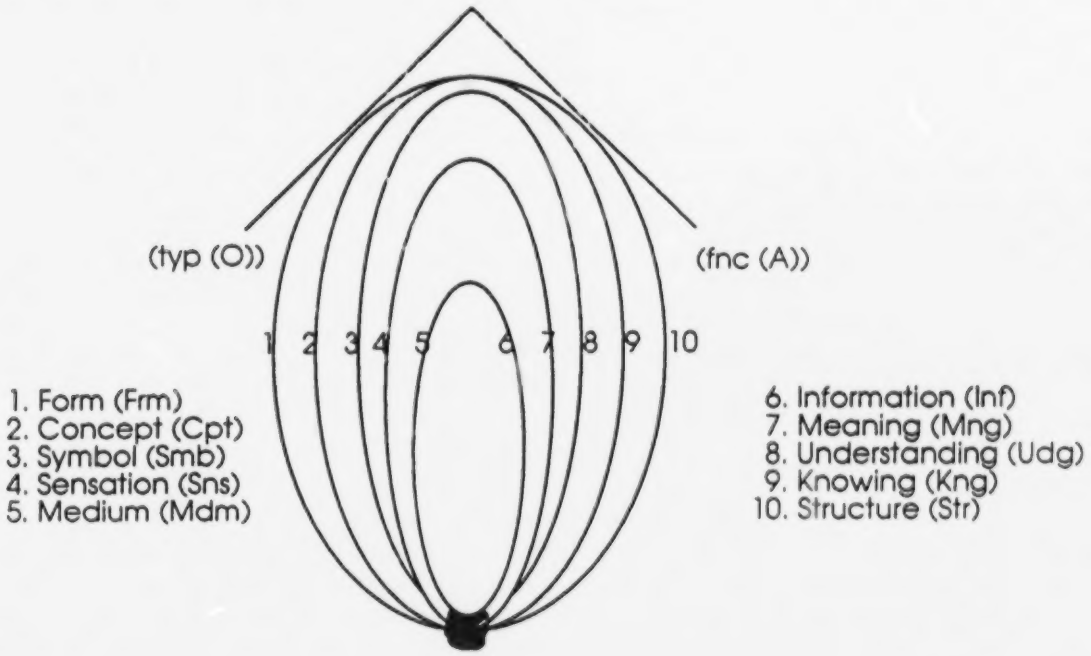
The notion "concept" labels the structural aspect of a graphical or symbolic expression, while the meaning of an expression is given by the coherence of its conceptual structure. The most important aspect of coherence is its indication of intention and orientation. Structured information is created when a communication process results in meaningful information. But informational value is relative to the way conceptualisations have been grounded in experiences. For example, linguistic form is used to express both intentionality and orientation. Changes in degree of abstraction and form of symbolism may be seen as clear indicators of peoples' understanding of their language and insight with respect to the empirical phenomenon under investigation. Thus linguistic form can provide direct links between information and structure.

The present Phase (III) advances the process of differentiation and integration into a state that is characterised by a manipulation of " type" (typ (O)) and "function" (fnc (A)). As shown in Figure (4) fixation of both means stipulating the *zero hypothesis of cognitive processing*. Under this condition conceptualisations are integrated into a "word-concept" that can be labelled. The problems of how people come to concepts (2) has been governing even those cognition models that have their anchorage in semantic-logical assumptions. Mobilising both factors would imply a synthesis leading to knowing (9).

What can be differentially approached and measured in this new Phase are the variations in form (1) and variations in structure (10). The notion "structure" here refers not only to the process of construction but also to the actual components and their relations within a given unity. It should be understood that one cannot point to a structure. Therefore, it is always necessary to state its "form" of organisation. Thus, the term is not used merely to make reference to stability. A structure may remain stable over long periods of time or it may change from moment to moment, but this depends on the characteristics of the ongoing cognitive processes within a structure. This definition explicitly recognises that "form" and "structure" are interacting and that all changes of information over time may be regarded as process. Consequently, it should be impossible to speak of the "structure of neural networks", the "structure of electronic circuits", or the "structure of linguistic elements and semantic properties", because this would confuse the notion structure with the notion of generalised patterns (Bursen, 1978).

The implications of coding "word-concepts" on the basis of semantic markers is demonstrated with Collins and Quillian's (1969) cognitive model. It was developed with the understanding that cognition should be expressible through computer programs, since it has been possible to construct an isomorphic relation between symbolic logic and arithmetic. Through this isomorphism propositional logics could be given the form of arithmetic procedures. As a consequence, a number of syllogisms could be computed through completely automatised procedures. This successful manipulation of logical formulas was further taken as a pretext for the hypothesis that humans should have computable knowledge about the adequate response. It may be noted that Collins and Quillian assume that "semantic concepts" represent a "bundle of properties", were the properties are interrelated through associations. These types of concept constitute the result of a coder's manual effort to mark semantic relations and to connect them in agreement with rules of predicate-logics. Typical for this circumstance is that everything is presented in discrete form, the essential characteristic of computing concepts. A semantic net represents a collection of frozen symbols in which many of the discontinuous variables, necessary for a conceptualising process are missing. The computationally anchored belief of cognition produces no link for testing substantial hypotheses about cognitive behaviour, i. e. recognition. It is not even possible to test the sensitivity of the model.

Figure 4. Phase III. Conceptual Information Processing



Varying actors and events in social scenarios. If intelligent machines shall be developed, some principles of organisation should be employed that stipulate a reference to meta-knowledge, which lies outside both syntactic and semantic-logical specifications. An awareness of this has governed Abelson's (1973) attempts to construct a formalism (1) and to operationalize it by building an ideology machine. His approach is used (B. Bierschenk, 1990 c) to demonstrate what it means to assume social events to have structure. Abelson's basic premise is that concepts and conceptual relations differ depending on Eastern and Western ideologies. But since this may not be discernible on a philosophical level, the word-concepts are assigned social attributes, which means that they represent events of a certain social type. Consequently, the ideology machine must classify such events in order for cognitive organisation to emerge. The central roles are played by actors within a context of social scenarios. As in any other social contract, certain specific rules control that their actions conform with predetermined classifications. It follows that the cognitive mechanism operates on stereotypic situations, the ideology machine's way of avoiding or circumventing context.

Evidence and beliefs as behavioural condition. In contrast to Abelson's simulator Colby (1973) presents a belief system in which conceptual processing is thought to lead to changes in cognitive structure. Because his approach concerns a state change, the basic premises are different concerning belief structures (10). Colby assumes that humans do not react on events by attributing causes to them from a background of standardised knowledge. According to him, an adult person selects, transforms and organises beliefs on the basis of actions. The model is presented in graphical form (B. Bierschenk, 1990 a) and it is shown how it becomes possible to name concepts and give an unambiguous definition of what is meant by conceptualising. The cognitive structure studied is the one assumed to be known as paranoia. Characteristic for the system is that selection is simulated with a matching mechanism, which investigates and compares the intensity of different beliefs. Transformations are depicted through an algorithm associating keywords to concepts. The mechanism is used to demonstrate the cognitive power of the system. Of course, the *context* of paranoid actions is

framed, too, only in a different sense. In conclusion, political and personal beliefs are thereby forced into an artificial world without any anchorage in real world events, which means that a belief cannot be differentiated from its representation.

In research on contour coding, the line function has been used to study experimentally how an organism comes to meaning (Phase I) and understanding (Phase II). But the line has also been the starting-point to illustrate that structural transformation of the edges of a surface is necessary, if it shall lead to structural information (Phase III). In the following a contour coding experiment is presented with the purpose of demonstrating the inherent character of knowing a concept (9). It is shown that Gibson's assumption of "super ordinate components" can be used to establish ageing in faces. This implies that conceptual relations need not be conceived in totality to be an active part in cognitive processing.

In this sense, a concept is made up of dynamic and abstract relations whose boundaries are cognitively determined. This means that the individual's experiences can be successively integrated within this structure, enabling the concept to grow with the individual's experiential development. From the ecological point of view concepts are emergents. They may be conceived of as complex events. The perception of them, therefore, requires coping with change as opposed to the perception of objects. This kind of change is structural, however, and thus non-trivial. The perception of concepts encompasses an identification of the structure that remains over change, which means that its boundaries cannot be infinitely stretched. The growing of a concept is a preservation of structural invariance over time. This should have as its consequence that it is possible to directly perceive a concept once the structure has been determined and cognised, and that therefore the growth itself, the remodelling transformation process, would be perceivable as well. The very nature of this approach will be illustrated with the concept of "growth", because growth implies a systematic movement in which both change and non-change are unified making it immediately detectable.

Distinction and abstraction of regularities in change. Pittenger and Shaw (1975 a, 1975 b) have studied transformation and growth in two experimental settings where perception of ageing head profiles and faces were measured. They were concerned with the perception of events in which object configurations or the shapes of the objects undergo dynamic change. Growth is here considered to be an viscal-elastic event which can be described in two dimensions. The viscal component carries the structural invariance specifying the identity of the growing face, while the elastic component carries the transformational invariance, specifying the style of change to be detected. Since growth must be regarded as an event, structural invariance is non-static. Thus changes over both dimensions should contribute to the growth process and should be subjected to the study of perception of ageing. With the goal of examining the perceptual effect of the elastic component of the remodelling transformation, the reported studies on growth were carried out as a series of Monte Carlo experiments. The first experiment tested the effects of shape change. The second experiment tested "subject's" sensitivity to very small changes in the relative shapes of simulated profiles. A further experiment revealed that the transformation did not destroy the identity. On the basis of these experiments it is clear that the shape of an object is not the primary information provider for perceptual identification, since form perception is just a special case of event perception.

Simulation of behaviour strategies. When *context* is used as controlling device in simulation, both *events* and *actions* must be discerned and kept apart. By the appearance of an event, it should be possible to know, what action preceded it and what should be the anticipated consequence. With this view, a simulation system would consider the interaction between an individual who acts and a context, in which events occur. One approach of this kind is presented (B. Bierschenk, 1978) whose basic premises are the following. One and the same phenomenon can be differentially specified through *event sequences* characterised by different affordance structures. In simulation of this kind, *abstract* events need to be structured such that they can be reflected in language formulations. Characteristic of these abstract events

is that they require the specification of higher-order components as well as their co-operation. In contrast to naturally occurring events, the events conceptually defined are founded on the idea that human behaviour cannot be understood independent of a psychological model. Therefore, the simulation model has been constructed in such a way that the individual gets control over the context of his actions. The utilisation of this control function makes it possible to create one's own world. In this process, both visualised and verbalised information has to be processed in a co-operative manner. In analysing the resulting action-event sequences the language part needs to be analysed with Perspective Text Analysis (Bierschenk & Bierschenk, 1986 d), because the underlying model has the capacity of reflecting the informational invariants being in the flow of the simulation process. Concludingly, an attempt is made to demonstrate whether and in what sense the individual's *knowing* the significance of the strands (i. e. the higher-order relations) lying in the texture of the context, is reflected in the course of action taken.

Thus a simulated concept cannot be and needs not be captured in its entire dimensionality in order to be understood. In the case of "growth" two components were enough for simulation, which means that it was possible to observe the concept, i. e. existence of structure. In the case of the behavioural simulation one did not know, if a structure existed, only that there were co-operative activities. Those activities were demonstrated to be of a co-ordinative nature, which means that relations were created and broken during the discourse, leading to the discovery of structure. As long as the existence of structure has not been detected, one may hardly talk about *the* concept either, a reason why a "word-concept" is not directly observable. It is frozen. Growth, on the other hand, has a discoverable structure, which was unfreezed, and consequently could be discovered by direct observation in an experimental setting. This is one way of making the concept visible. On the other hand, in simulating simple events, making up a strategy of behaviour, the basic concepts of "association", "structure", and "process", could be specified and made known. Thus knowing that structure exists means that formless and timeless invariants can be named.

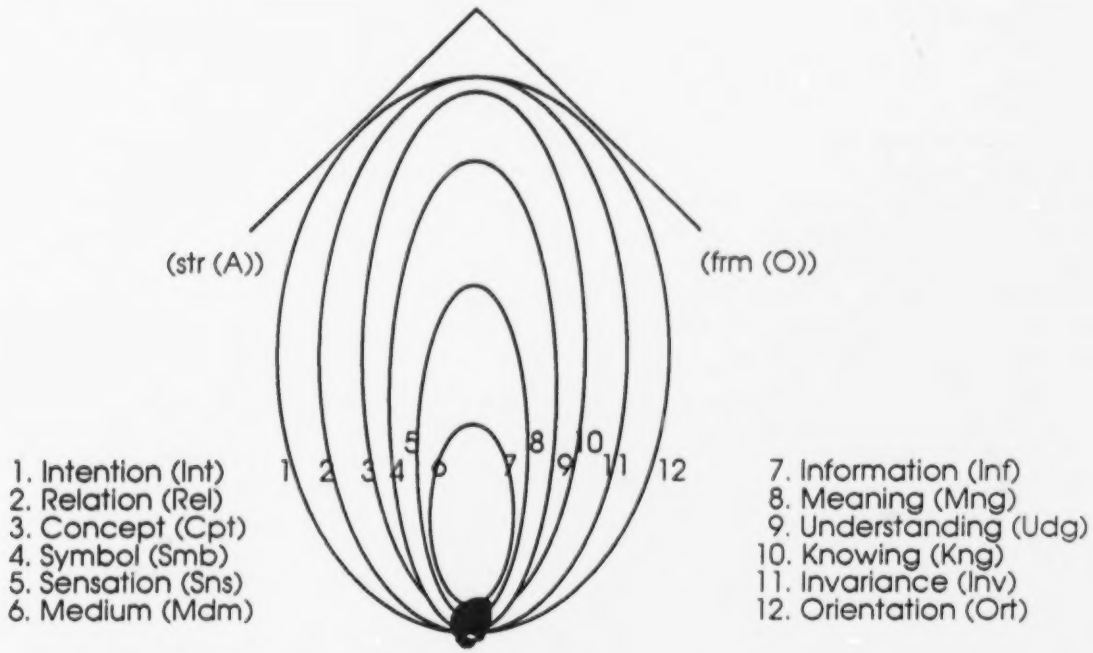
The difference between "growth" and the concept of association, for example, is easily explained by the AaO-model. The first has reached a phase where its boundaries are defined and aspects (such as ageing) easily symbolised. The latter is not in this state. As unfreezed concept it is in the coming while the simulation process develops into its final state. This explains why the concepts, constituting the fundamentals of behavioural simulation, are deeply embedded and can be made observable only during a discourse. As expressed by the notion "label" a concept under the condition (2) is shallow, i. e. without any discoverable structural component at the beginning. It only addresses complexity in texture. However a label like "association" may gain structural momentum, and thus be understood by experimental subjects as expressions of special value. The information that a concept of a certain kind carries is dependent on the method used for generating it. This means that concepts can only be behaviourally defined. From an ecological point of view, the method is contextually determined in the sense that it may vary between disciplines or scientific communities. As a result, knowing may differ from one research environment to another. For example "association" may by differently conceived in the natural sciences compared to behavioural and social science research. Further, if the method governs the way of conceiving the research problems, or conversely, if the problem formulation has a steering effect on choice of method, then it should not be surprising that the structural invariance inherent in a certain concept shows dimensional diversity.

Representation of Knowledge

The advanced descriptive and theoretical formulations of the process comprises in its fourth Phase the possibility of an ecological orientation in the analysis of scientific information processing. In Phase (IV), the mechanism operates with "structure" (str (A)) and "form" (frm

(O)) as the independent variables of experimentation. In Figure (5) it is suggested that integrative processing generates relations (2). Thus a static structure and a frozen form constitute the *zero hypothesis for a study of the conceptual apparatus that underlies scientific change*. Mobilising both produces invariance (11). The differentiation process, resting on (12), produces "orientation" as the dependent variable, which represents features and attributes that can be measured in order to represent a scientific orientation (Broadbent & Broadbent, 1978). The differentiation process resting on (1) concerns the "intention" which can be represented and measured in the Piagetean sense.

Figure 5. Phase IV: Scientific Information Processing.



Piaget in his attempts to study knowledge as a process, takes his point of departure in the infant's behaviour of thumb-sucking, which he sees as the behavioural manifestation of a formal structure. Thus the infant's sucking is conceived of as part of a "sensory-action schema" and as one of the earliest schemata. It implies that even though an action may have occurred quite accidentally, it can provoke a repetition.

This can be illustrated with Becker's (1973) outline of the basic form of a schema in Piaget's sense: $Event_1$ -- $Action_1$ -- $Action_2$ -- $Event_2$. As indicated by this formalism, recursive actions are identified by the behavioural outcome they produce. Through events, which have as their consequence the repetition of acts, Piaget argues, simple schemata can be discovered. Through his schematising process the infant extends his repertoire of actions without any representation of thought (Piaget, 1978). According to Piaget, the operational schema is the basic control mechanism in the development of the organism's behavioural and cognitive abilities, because a cognitive schema is derived from the action schema by the postulated process of internalisation. What is internalised are the abstracted relations that gradually develop into operative structures. These become progressively integrated and differentiated. The mechanism stipulated by Piaget for the needed balancing between structural transformations and orientational shifts consists of "progressive equilibration" and "auto-regulation". Through systematic observations of the child's activity, Piaget was able to show

"persistence in perspective" which he takes as a measure of intentionality (1), even though the child's orientation (12) may change fairly rapidly. Thereby it is assumed that the schema is the basic mechanism for self-organisation, primarily through procedurally based recurrent activities. Consequently, the function of the schema should be observable in the development of a formal cognitive *organisation*, i. e. knowledge.

If a conceptual structure is to be studied with respect to the position of a certain concept within it, it becomes possible to elucidate structural change not only in the cognitive structure of a particular human being but also in the transformational change of concept structures within and between subject fields or disciplines. The focus, therefore, is on the procedural aspect of cognitive structure as expressed through various organising principles (B. Bierschenk, 1991 a). Above all, two problems have been accentuated. The first one concerns the construction of a information system, while the second concentrates on questions of knowledge representation. Organisation, irrespective of the order principle chosen, presupposes both a possible way of formalising knowledge and a psychological basis. The attribute "cognitive" is in the computer sciences very frequently used to label aspects which are not easily expressed by formal definitions. With this in mind, the discussion centers partly around the mechanism supposed to exist in language and its appropriateness for algorithmisation, partly around the need for a re-definition of verbal expressions to be used with the aim to differentiate cognitive structure from its representation.

Relations in the organisation of information. The discussion starts off with the institutionalised organisation of knowledge based on some widespread order principles, which are illustrated. It is demonstrated how syntactic components are taken to be the unquestionable foundation for a propositional representation of knowledge. Moreover, it is shown how semantic components are used in specifying lexical entries. As a rule, both types of components are used in combination with the expectation of designing representations that are error-free, complete, and well-defined.

What consequences this may have for the construction of a scientific information system is studied by I. Bierschenk (1981) and illustrated with the French SYNTOL (Coyaud, 1966). In this system it is assumed that the links to scientific context are of subordinate import in favour of formal aspects reflected in established subject knowledge. In this system the classification mechanism relies on processing of syntactic associations which are constructed with the purpose of controlling explicit relations, while implicit relations are controlled by generalised propositions. Information processing in this sense, therefore, means that both explicit and implicit foundations of conceptualisations are equated with *"logical invariance"*, which is given a semantic interpretation. As shown (B. Bierschenk, 1984 b) this same view was taken by Becker (1973), when he tried to simulate how an organism acquires meaning. Thus when the knowledge of an organism or an organisation for that matter, is reflected by the concepts being given lexical relationship, the view of knowledge assumes the representation to be universal.

Analysing scientific discourse. The creation of order presupposes a form of organisation within which the order can be set up. A novel approach is presented (I. Bierschenk, 1981). This work shows how a cognitively determined definition of scientific discourse can be given a formal expression through an algorithm for processing scientific concepts and conceptual relations. The task of creating order between scientific observations first of all implies their determination. A description without due consideration of research methods in the representation of scientific concepts lacks contextual anchorage. Scientific concepts are communicated through scientific documents, whose various statements are based on empirical observations about events. Thereby it is implicitly stated that prototypical forms are *recurrent* and observable. This means that they can be formalised and named. The basic linguistic elements used to relate concepts and to structure reality are the prepositions. By means of the structural principles underlying the AaO-model, the cognitively based use of prepositions

illustrates in what way scientific *intention* and *orientation* have significance in the representation of knowledge.

Whether the model is flexible enough to reflect changes in conceptual orientation (12) and intention (1) is studied in the process of building up a structure and in producing a form. The process is illustrated with examples from transformational phase transitions. By examining the co-variation of formally defined concepts and conceptual relations with their informal definitions, it was possible to reveal such dimensions that a manual analysis with a classical orientation towards philosophical classification schemes (e. g. English PRECIS index system, Wellisch, 1977) could not have performed. By contrasting the outcomes of various conceptual transformations with semantic-logical approaches, it is demonstrated in what way the development of a concept is reflected in its formulation in scientific work.

It can be concluded that the basic premise on which the AaO-model rests, is that processes of conceptual differentiation and integration can be studied with respect to their structural specification. Thereby it is also stated that significantly more attention has to be payed to adult's concept formulation strategies. After all, linguistic formulation reveals or hides perspective information pertaining to the conceptualisation of empirical observations.

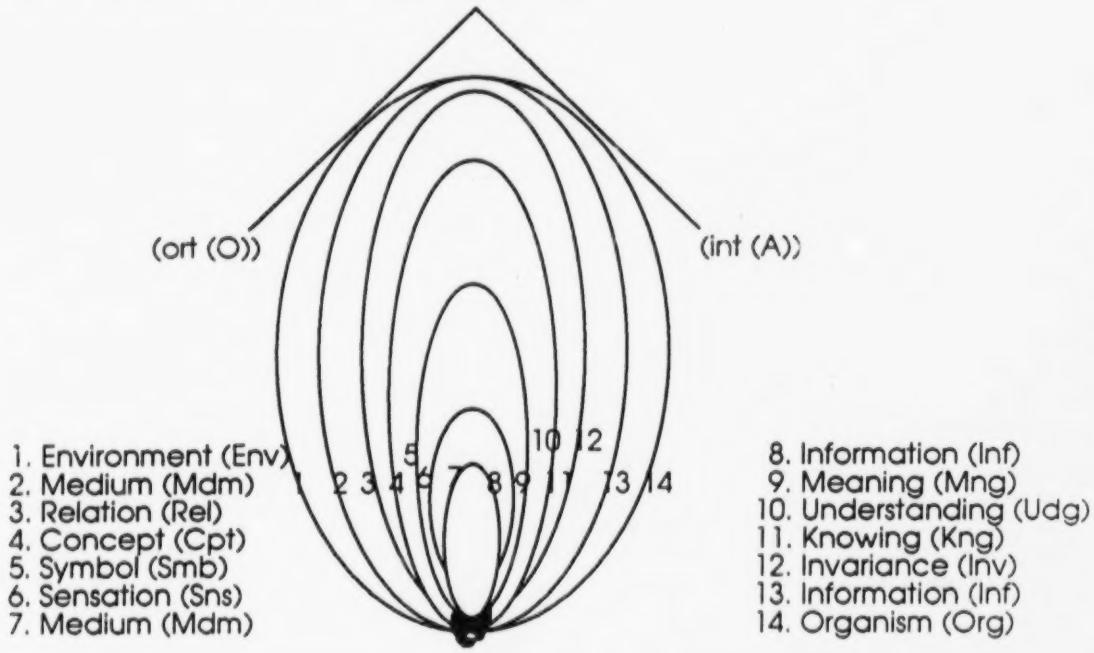
Affordance in Metaphors

The course of the developing process has now reached a point where the helical configuration makes obvious a "perceptual shift" concerning the experimental variables and the variables of measurement. In relation to these variables Phase (V) is formally identical with Phase (0), though the whole architecture has gained a momentum that is unmatched by preceding configurations. In Figure (6) the co-operation between "orientation" (ort (O)) and "intention" (int (A)) is no longer the objective of a literal interpretation. Instead, it is the virtual, i. e. the meta-phorical determination of terminal states that comes into focus. In B. Bierschenk (1991 b) the discussion of the metaphor as instrument for naming the terminal states of ecological invariants follows two lines. The first one concerns its linguistic form and semantic interpretation as well as the literary explanation. Here the focus is on linguistic rules and their possible adaptation. The second line taken, focuses on the metaphor as cognitive instrument, which necessitates that problems are highlighted that pertain to the choice of criteria for determination of what constitutes a metaphor.

Phenomenological givens in social frames. As a background some conventional strategies and the effects of contextualising are presented to introduce the user perspective. Implicit figuration and subjective interpretation make up the basis of the classical discussion of the comprehensiveness and aesthetic qualities of metaphors. Its functioning and use in the social sciences is illustrated through the work of Schön (1979), who introduces the "generative metaphor" as an instrument for the analysis of phenomenological givens.

The assumption of structural similarity. The starting-point taken is the common understanding of the metaphor. A series of studies (Verbrugge & McCarrell, 1977) concentrates on the characteristics of the *ground* of the metaphor, but postulate instead of the common emotional quality the existence of "structural resemblance". With this orientation the experiments were meant to give evidence for the ecological significance of the metaphor. What is conceived by this notion has been analysed as well as the material used. Because Verbrugge and McCarrell tried to show that linguistic form and the relations inferred are central, they have concentrated their efforts on a demonstration that the *ground* has structural properties. This goal has been the justification for inquiring into the appropriateness of the authors' approach to capture the structure of cognitive events (B. Bierschenk, 1991 b). Especially Verbrugge's (1977) ecological approach to metaphoric comprehension and his hypothesis of direct perception of event structures embedded in the ground of a metaphor have given rise to a critical investigation into the authors' experimental decomposition of the metaphor.

Figure 6. Phase V. Virtual Information Processing



A pillar in Gibson's ecological approach is the theory that perception is founded on the organism's terrestrial environment, which has structure. Starting from structural invariance called affordance, he formulates the hypothesis that the organism needs to have developed a mechanism that makes possible an orientation through perception of environmental "reflectance" the way it emerges in a medium suitable for particular organisms, such as air and water. The difficulty with a direct transference of this definition is that event structure is hard to demonstrate at the same time as it is hard to imagine how this continuity in the environment may effect the organism's actions. In B. Bierschenk (1991 b) the effort, therefore, has been put on making explicit how the metaphor may be used as a means by which the environment can be known when the medium for reflecting structural qualities is assumed to be conceptual relationships made visible in language in such a way that conceptual information can be detected. By means of Perspective Text Analysis it is demonstrated that the metaphor has to be conceived of as the "*Re-naming Instrument*". The hypothesis tested is that the metaphor carries ecological information to be re-named. The results of the analysis show that the metaphor has to be treated as a self-contained verbal expression of affordance. By naming the affordance, i. e. what object and events the environment offers, events of a certain kind are brought into novel perspective.

The metaphor in scientific use. In the ecological oriented AaO-model of the metaphor the ground component denotes just what is not relative or personal, only the ecological significance. Anything else is groundless. However, as instrument for cognitive transformation the metaphor would have to get the names of the other components changed to make them more functional. The invariance expressed in the ground is arrived at through transformation. At the same time, this means that it does not only exist, but is directed in an abstract sense. To fulfil the transformation something has to give directiveness to the intention. This is the function of the orientation. Orientation in the cognitive sense denotes neither topological nor figural aspects, but rather it is the sense of meaningful behaviour, the proper denial of intransitivity. In fact every meaningful behaviour intertwines both intention and orientation. Therefore, "Tenor" or "Topic" will in the following discussion be replaced by ***"Intendor"*** and

"Vehicle" by ***"Orientor"***, in the hope that this redefinition and renaming may give insight into the development of novel perspectives in the study of cognitive behaviour in a wide sense.

Intendor and Orientor. It is a well-known fact that metaphors are central in the development of scientific hypotheses. This is particularly striking in Lorenz' approach, where he orients himself by the hydro-mechanical model in approaching species-specific behaviour. Despite the fact that this Orientor has an immanent character, while the Intendor is immaterial in nature, Lorenz has been able to generate many hypotheses of great value for theory development. His insight into the necessity of making the distinction between a conceptual and a phenomenological level of information processing has led him to pick up the invariance of explosive events, which gave rise to the hypothesis of a procedural schema, called the "Innate Release Mechanism". This means that Lorenz departs from the schema in the Kantian sense (Lorenz, 1941). The distinction in Lorenz' language concerning model and phenomenon shows that concepts like "energy", "storing", "flow", "overflow", and "explosion" are theoretically unambiguous and well anchored in hydro-mechanics (Lorenz, 1950; Hinde, 1955).

In contrast to Lorenz' conduct to theory development, Tinbergen (1951) has chosen to represent species-specific behaviour in form of a frame-model that hierarchically organises centra in the nervous system. Thus behaviour is equated with its representation. His understanding of behaviour has been popular in information processing circles, because it is explained in relation to the electro-chemical mechanisms of nervous systems. The model assumes the existence of one-way causality between particular centra and species-specific movements. His language presupposes the existence of some accumulated reaction specific energy in the organism. Moreover, it is postulated that a relation between internal inhibitory mechanisms and behaviour exists. Tinbergen's language describes behaviour as a set of states connecting his constructions of behaviour theory to equilibrium. As a rule, "Fixed Action Patterns" are postulated, implying that the purpose of species-specific behaviour is implicit and, therefore, needs not be sensitive to context. However, there is no empirical evidence for this existence postulate. Experiments with genetically encoded behaviour pattern (Immelmann, 1979) show that the environment in determinable ways influences the development of a behaviour. In order to make this insight apparent and to stress the fact that inherited behaviour patterns are far less "fixed" then postulated by Tinbergen's theory "Modal Action Patterns" have replaced the original expression. Modal Action Patterns imply that individuals do not simply react to external influences. They select, transform and organise information. Since no evidence exists for the assumption of self-organisation in Tinbergen's theory, which is dependent on constant exchange with the environment, concepts such as "flow" as well as "overflow" are theoretically empty.

Although it is of no primary concern in the present context to discuss the brain-computer "metaphor" favoured by researchers working with connectivity-based models (Bursen, 1978; Strube, 1990) a short excursion into their arguments would not be out of place. Because Tinbergen's description of "Fixed Action Patterns" has served in the discussion regarding the architecture of nervous nets, the machine-behaviour pair had significant implications for the understanding of human information processing and the representation of "computer behaviour". It may be worthwhile to mention that McCulloch and Pitts (1968) have tried to give evidence of a formal identity between neural nets and a theoretical machine. Moreover, it seems to be tempting, especially from a neurophysiological point of view, to perceive brain processes as results of the flip-flop mechanism (Young, 1978) and to postulate an "on-centre off-surrounding" system (Grossberg, 1982) working with symbols. Craik (1943), in particular, stated that the brain can only behave the way it does, if environmental relations become represented in the form of symbols. Within Cognitive Science Newell (1981) and Simon (1981) seem to use the computer as their Orientor when they equate cognition with representation. Strictly speaking, representation is commonly used synonymous with cognition. So, their position is widely accepted and, therefore, has far-reaching consequences for theory

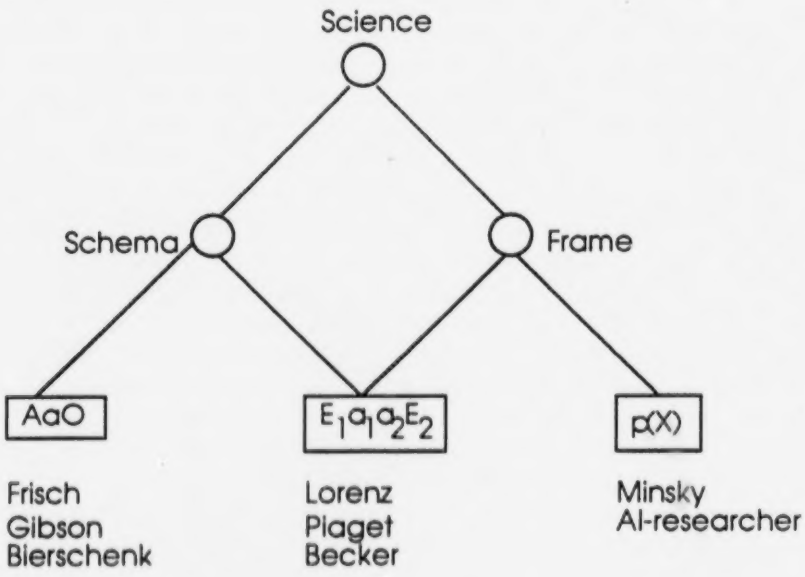
construction. Most conspicuous of this orientation is the use of concepts such as "information", "storing", "flow" and "overflow" as well as "combinatorial explosion". These are discussed as if they were well anchored in theory and generally understood. In theories based on connectivity, they are made use of as self-evident denotators of operations whether machine or organism specific.

Discussion

It should be logical to expect in the efforts of establishing Cognitive Science that the notions of analysis and synthesis play a central role. Indeed and most profoundly, they do not. Instead, Cognitive Science researchers conceive of the human mind in terms of universals in Leibnitz (1646-1716) sense. Leibnitz claimed the possibility of computing concepts on the basis of univocal parcels or bits on which a pure syntactic calculator could operate. With the new idea, formulated as the schema axiom, a split occurred with Kant's (1724-1804) introduction of the distinction between analytic and synthetic statements. This event produced an intellectual bifurcation in the history of science and consequently a dividing line in the study of knowledge as is summarised in Figure (7).

The majority of studies in Cognitive Science is based on rigid and resolutely static frames, originating from Minsky's (1975) research. As a consequence understanding is treated as operations suitable for a positionally defined processing of data input. Within this development, cognitive processes are explained with reference to "knowledge representation" based on p(x)-statements and text processing takes its point of departure in questions like: Are there properties and relations in a natural language that are suitable for a machine to utilise when it shall perform certain specific tasks within a well-defined frame of reference? The answer to this kind of questions are presented as the "objective knowledge of the world", whose justification is that information processing builds on general principles on which a frame generator or Turing machine functions.

Figure 7. The Axiomatic Bases of Science



Seen within a human context, this strong machine orientation reflects nothing less then "bicamerality" in Jaynes (1982) sense. Drawing conclusions about the importance of intentionality concerning cognitive differences between people requires an approach that emphasises information processing within living systems, mainly because of the obvious confounding of information integration with its synthesis. The confounding relation (I-S) of Figure (8) is just an extreme instance of covariance of intention and orientation. The real difficulty of course is that intentionality can only be measured under a special design (Fig. 5). Because of this condition, the covariance of intentionality and orientation requires special attention when intentionality shall be made the experimental variable as for example in (Fig. 6).

Piaget, building on Lorenz' schema concept, pointed out that the schema is conserved in the behaviour of the organism itself. He conceives of the schema as basis for formalising internalised actions. His argument is that the preservation of a schema has no need of a *memory* or knowledge *representation*, because the schema of an action is "the quality in the action". Consequently, he studies the function of schemata in the development of knowledge. Thus cognitive organisation consists of a construction of operational schemata, beginning with the general co-ordination of actions. But this construction is brought about by means of a series of transformations, which implies that a schema is conceived of as an abstract relationship and that it is generalizable and not particular.

A consequence of this reasoning is that any meaningful analysis of cognitive development in relation to behaviour should be based on the conjunction of *intended* events and how these conjunctions restrict events as to which might follow. From this point of view, covariation and interaction of intention and orientation have as their natural consequence an abstract representation of what happened before and followed after the appearance of an event. Consciousness, founded on intentionality (Bierschenk, 1991 b) still is excluded in Piaget's approach, because it is in conflict with the laws of the conservation of energy. It was Gibson (1966, 1979), who claimed that an agent-oriented approach is the basis of ecological perception, because perceptual experience is direct and flows immediately from what he conceives of as the relationship of super-ordinate components, which is his definition of the invariants of structure.

Gibson claims in agreement with Kant, that the objective reordering of information picked up by the organism, actually is dependent on intentionality, i. e. synthetic reorganisation, which is an a priori act of human understanding. The unity signified by a symbol is achieved by this synthesising process, in which variety becomes specified. This is what Kant calls "lex continui in natura" (Cassirer, 1970, p. 48). The hypothesis of a schema was first utilised by Kant to label some cognitive mechanism, which he postulated necessary as mediator between such cognitive functions as categories on one hand and sensory input from the environment on the other. Consequently, Kant labelled the product of a schematising process "imagination" ("Einbildungskraft"). Further, Kant used the notion schema as expression of the transcendental law that establishes relations between events stretching over series of instances (Segmente einer Zeitreihe").

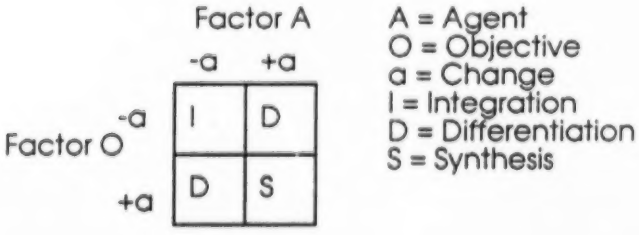
His argumentation, cast in modern thought, seems to imply that information is not a discrete commodity, but is transferred by physical carriers, such as books, electronic circuits, chemical substances, neural networks, or wing strokes, but it is not in itself material. It must be granted that the organism acts on symbols and that its behaviour expresses a high degree of schematism and structurisation. Thus, there is very little reason to doubt the Kantian basis in Frisch's experiments on the preciseness and completeness of a natural symbol system when used for communication in a natural context. Moreover, there is every reason to believe in peoples' ability to use their symbol system in specifying unambiguously their perception, because the schema in text building behaviour produces a "finger print" and as such defines the unique quality in a verbal expression.

According to the schema approach, subjective perceptual or mental states are emergents in the language space that become irreducible and indispensable for explaining conscious behaviour. This is in agreement with Sperry's (1993) position, who asserts that the brain differentiates interactive properties of perceptual activity and behavioural outcome on the basis of topological invariants. In Gibson's view, these make possible that the behaving organism can re-cognise (observe) itself through immediate information pick-up. He agrees that "sensation" (Fig. 2) or stimulus integration is necessary for the activation of the perceptual system. But the stimulation of the receptors in the retina, he points out, cannot be seen. Instead, the function of the retina should be thought of as a means of registering "invariants of structure" (Gibson, 1979, p. 56), which is to say the results of a synthesis. In Gibson's sense, the presented model may be conceived of as a hypothesis that is intended to close the gap between "physical" and "metaphysical" (Kant, 1975, p. 101) processing (Figs. 1 and 6).

This theory of information synthesis is acceptable only under the condition that it can be developed in the form of a system that has the capacity of describing a wide range of observations and experimental results. The conceptual foundation of the AaO-model governing the process of information pick-up, integration, differentiation and synthesis (Figs. 1-6) dictates how experiments have to be set up and interpreted. Moreover, the AaO-formula's development into a system influences the way in which experimental results are applied to the re-cognition of social problems.

The theoretical notions "intention" and "orientation" have been central in the instrumentation of the AaO-formula. Both constructs are needed to give expression to the co-operative interaction between the biologically endowed mechanism of information pick-up and the strategies of behaviour that can be conveyed by some optical display. In order to separate experimentally the effects of intention and orientation on a particular phenotypic behaviour, individuals with the "same" intention must be studied with respect to differences in orientation, and individuals with "different" intentions must be tested on tasks requiring "same" orientation according to the prototype of the factorial design given in Figure (8).

Figure 8. General Lay-out of the Recurrent Factorial Design for Assessment of Basic Concepts.



If non-change versus change in the agent's intention is subjected to differences in orientation then definite conceptual conclusions can be drawn about the information processing as shown by Frisch's experiments. Against this background the presented discussion has progressively been focused on difficulties that have appeared in the classical Cognitive Science studies that attempted to contribute to the understanding of cognition. Especially scientists working with the development of computer technologies, have repeatedly pointed out that they have constructed models for "knowledge representation" of significance for cognition and language research. The problem, however, is that their argumentation rests on a confounded design, namely on the (I-S) relation of Figure (8). In this case, it is impossible to ascertain whether the inferences, based on the relationship, concern the frozen or unfrozen factor A or factor O

respectively or both. This may be conceived of as an elementary point in the critic, but it is precisely this point which is ignored whether or not the studies concern phenomenological or conceptual distinctions.

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